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Statistics on Aircraft Gas Turbine Engine Rotor Failures that Occurred in U. S. Commercial Aviation During 1985

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July 1989

Final Report

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16. Abstract

This report presents statistics relating to gas turbine engine rotor failures which occurred during 1985 in U. S. commercial aviation service use. Two hundred and seventy-three failures occurred in 1985. Rotor fragments were generated in 150 of the failures, and of these 14 were uncontained. The predominant failure involved blade fragments, 94.4 percent of which were contained. Six disk failures occurred and all were uncontained. Fifty-seven percent of the 273 failures occurred during the takeoff and climb stages of flight.

This service data analysis is prepared on a calendar year basis and published yearly. The data support flight safety analyses, proposed regulatory actions, certification standards, and cost benefit analyses.

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EXECUTIVE SUMMARY

This service data analysis is prepared on a calendar basis and published annually. The data support flight safety analyses, proposed regulatory actions, certification standards, and cost benefit analyses. The following statistics are based on gas turbine engine rotor failures that have occurred in United States commercial aviation during 1985. Two hundred and seventy-three rotor failures were reported in 1985. These failures accounted for approximately 17 percent of the 1653 shutdowns experienced by the United States commercial fleet. Rotor fragments were generated in 150 of the failures and, of these, 14 were uncontained. This represents an uncontained failure rate of 1.3 per million gas turbine engine powered aircraft flight hours, or 0.5 per million engine operating hours. Approximately 10.6 million and 25.6 million aircraft flight and engine operating hours, respectively, were logged in 1985.

Turbine rotor fragment-producing failures were approximately two and one-half times greater than that of the compressor rotor fragment-producing failures; (103 and 40 respectively, of the total). Fan rotor failures accounted for seven of the fragment-producing failures experienced.

Blade fragments were generated in 142 of the rotor failures; eight of these were uncontained. The remaining eight fragment generating failures were produced by disk and seal.

Of the 152 known causes of failures (because of the high percentage of unknown causes of rotor failures, the percentages were based on the total number of known causes), the causal factors were (1) foreign object damage--72 (47.4 percent); (2) secondary causes--57 (37.5 percent); and (3) design life prediction problems --17 (11.2 percent). One hundred and fifty-six (57.1 percent) of the 273 rotor failures occurred during the takeoff and climb stages of flight. Ninety-nine (65.6 percent) of the 151 rotor fragment-producing failures and eight (60 percent) of the 14 uncontained rotor failures occurred during these same stages of flight.

The incidence of engine rotor failures producing fragments has increased 31.6 percent when compared to 1984 (114 in 1984 and 150 in 1985). The number of uncontained engine rotor failures reported has decreased 22.2 percent in 1985 (18 in 1984 and 14 in 1985). The 11-year (1975 through 1985) average of uncontained engine rotor failures is 15.1.

INTRODUCTION

This report is sponsored and co-authored by the Federal Aviation Administration (FAA) Technical Center, located at the Atlantic City International Airport, New Jersey.

This service data analysis is published yearly. The data support flight safety analyses, proposed regulatory actions, certification standards, and cost benefit analyses.

The intent and purpose of this report is to present data as objectively as possible on gas turbine rotor failure occurrences in U.S. commercial aviation. Presented in this report are statistics on gas turbine engine utilization and failures that have occurred in U.S. commercial aviation during 1985. These statistics are based on service data compiled by the FAA Flight Standards District Office. The National Safety Data Branch of the FAA Aviation Standards National Field Office disseminated this information in a service difficulty data base and the Air Carrier Aircraft Utilization and Propulsion Reliability Report. The FAA service data base contains only a fraction of the actual commercial helicopter fleet operating statistics. The number of turboshaft engines in use with the corresponding engine flight hours given herein are estimates derived primarily from statistics published by the Helicopter Association International in their helicopter annuals. The compiled data were analyzed to establish:

1. The incidence of rotor failures and the incidence of contained and uncontained rotor fragments (an uncontained rotor failure is defined as a rotor failure that produces fragments which penetrate and escape the confines of the engine casing).

2. The distribution of rotor failures with respect to engine rotor components, i.e., fan, compressor or turbine rotors and their rotating attachments or appendages such as spacers and seals.

3. The number of rotor failures according to engine model and engine fleet hours.

4. The type of rotor fragment (disk, rim, or blade) typically generated at failure.

5. The cause of failure.

6. The flight conditions at the time of failure.

7. Engine failure rate according to engine fleet hours.

RESULTS

The data used for analysis are contained in appendix A. The results of these analyses are shown in figures 1 through 7 and tables 1 and 2.

Figure 1 shows that 273 rotor failures occurred in 1985. These rotor failures accounted for approximately 16.5 percent of the 1653 shutdowns experienced by the gas turbine powered U.S. commercial aircraft fleet during 1985. Rotor fragments were generated in 150 of the failures experienced and, of these, 14 (9.3 percent of the fragment-producing failures) were uncontained. This represents an uncontained failure rate of 1.3 per million gas turbine engine powered aircraft flight hours, or 0.5 per million engine operating hours.

Approximately 10.6 million and 25.6 million aircraft flight and engine operating hours, respectively, were logged by the U.S. commercial aviation fleet in 1985. Gas turbine engine fleet operating hours relative to the number of rotor failures and type of engines in use are shown in figure 2.

Figure 3 shows the distribution of rotor failures that produced fragments according to the engine component involved (fan, compressor, turbine), the type of fragments that were generated, and the percentage of uncontained failures according to the type of fragment generated. These data indicate that:

1. The incidence of turbine rotor fragment-producing failures was approximately two and one-half times greater than that of the compressor rotor fragment-producing failures; these corresponded to 103 (68.7 percent) and 40 (26.7 percent), respectively, of the total number of fragment-producing failures. Fan rotor failures accounted for seven (4.7 percent) of the fragment-producing failures experienced.

2. Blade fragments were generated in 142 (95 percent) of the failures; eight (5.3 percent) of these were uncontained. The remaining eight (6 percent) rotor fragment failures were produced by disk and seal. All of the six disk failures were uncontained.

Figure 4 shows the rotor failure distribution among the engine models that were affected and the total number of the models in use.

Table 1 contains a compilation of engine failure rates per million engine flight hours according to engine model, engine type, and containment condition. The engine failure rates per million flight hours by engine type are turbofan/turbojet--10.6, turboprop--13.8, and turboshaft--3.4. Uncontained engine failure rates per million flight hours by engine type were turbofan/turbojet--0.5 turboprop--none, and turboshaft--2.4.

Figure 5 shows what caused the rotor failures to occur. Of the 152 known causes of failure (because of the high percentage of unknown causes of rotor failure, the percentages were based on the total number of known causes), the causal factors were (1) foreign object damage--72 (47.4 percent); (2) secondary causes --57 (37.5 percent); and (3) design and life prediction problems--17 (11.2 percent).

Figure 6 indicates the flight conditions that existed when the various rotor failures occurred. One hundred and fifty-six (57.1 percent) of the 273 rotor failures occurred during the takeoff and climb stages of flight. Ninety-eight (65.3 percent) of the rotor fragment-producing failures and 8 (57 percent) of the 14 uncontained rotor failures occurred during these same stages of flight. The highest number of uncontained rotor failures, 6 (42.9 percent), happened during takeoff.

Table 2 is a cumulative tabulation that describes the distribution of uncontained rotor failures according to fragment type, engine component involved, cause category, and flight condition (takeoff and climb are defined as "high power," all other conditions are defined as "low power") for the years 1976 through 1985. This table is expanded yearly to include all subsequent uncontained rotor failures. These data indicate that for secondary causes the number of uncontained failures was approximately five times greater at "high" power than "low" power (namely 31 and 6); and for "foreign object damage," the number of uncontained failures was eight times greater at "high" power than "low" power (namely 8 and 1). This tabulation also indicates that of the 152 total uncontained incidences, blade failures accounted for 67.1 percent; disk failures 22.4 percent; rim failures 4.6 percent; and seal/spacer failures 5.9 percent.

Figure 7 shows the annual incidence of uncontained rotor failures in commercial aviation for the years 1962 through 1985. During 1985, the incidence of uncontained rotor failures decreased by four over the previous year, 1984. Over the past 11 years, 1975 through 1985, an average of 15.1 uncontained rotor failures per year have occurred. During the same time period, the rate of uncontained rotor failures has remained relatively constant at an average of approximately one per million operating hours.

DISCUSSION AND CONCLUSIONS

The incidence of engine rotor fragment-producing failures has increased 31.6 percent when compared to 1984 (114 in 1984 and 150 in 1985). The number of uncontained engine rotor failures has decreased 22.2 percent (18 in 1984 and 14 in 1985). The 11-year (1975 through 1985) average of uncontained engine rotor failures is 15.1.

Of the 14 uncontained events that occurred during 1985, 8 (57 percent) involved turbine rotors, 3 (21 percent) involved compressor rotors, and 3 (21 percent) involved fan rotors.

The predominant cause of failure was attributed to foreign object damage (47.4 percent of the known failures) and one uncontained failure occurred in this category. Secondary causes (37.5 percent of the known failures) and design and life prediction problems (11.2 percent of the known causes) had two and one uncontained failures, respectively. The causes of the remaining 10 uncontained failures (71 percent) are unknown.

Uncontained failures occurred in 4 of the 10 flight modes; i.e., 6 during takeoff (42.9 percent); 2 during climb (14.3 percent); 5 in cruise (35.7 percent), and 1 in hovering (7.1 percent).

The higher incidences of uncontained rotor failures in calendar years 1967 through 1973 (except for 1968) were probably due to the introduction of newly developed engines entering the commercial aviation fleet, such as the JT9D and CF6 engines.

Structural life predictions and verification are being improved by the increased use of spin chamber testing by government and industry as a means of obtaining failure data for statistically significant samples. In addition, increased development and application of high sensitivity, nondestructive inspection methods should increase the probability of cracks being detected prior to failure. The capability to reduce the causes of failures from secondary effects is also being addressed through technology development programs. However, causes due to foreign object damage still appear to be beyond the control or scope of present technology.

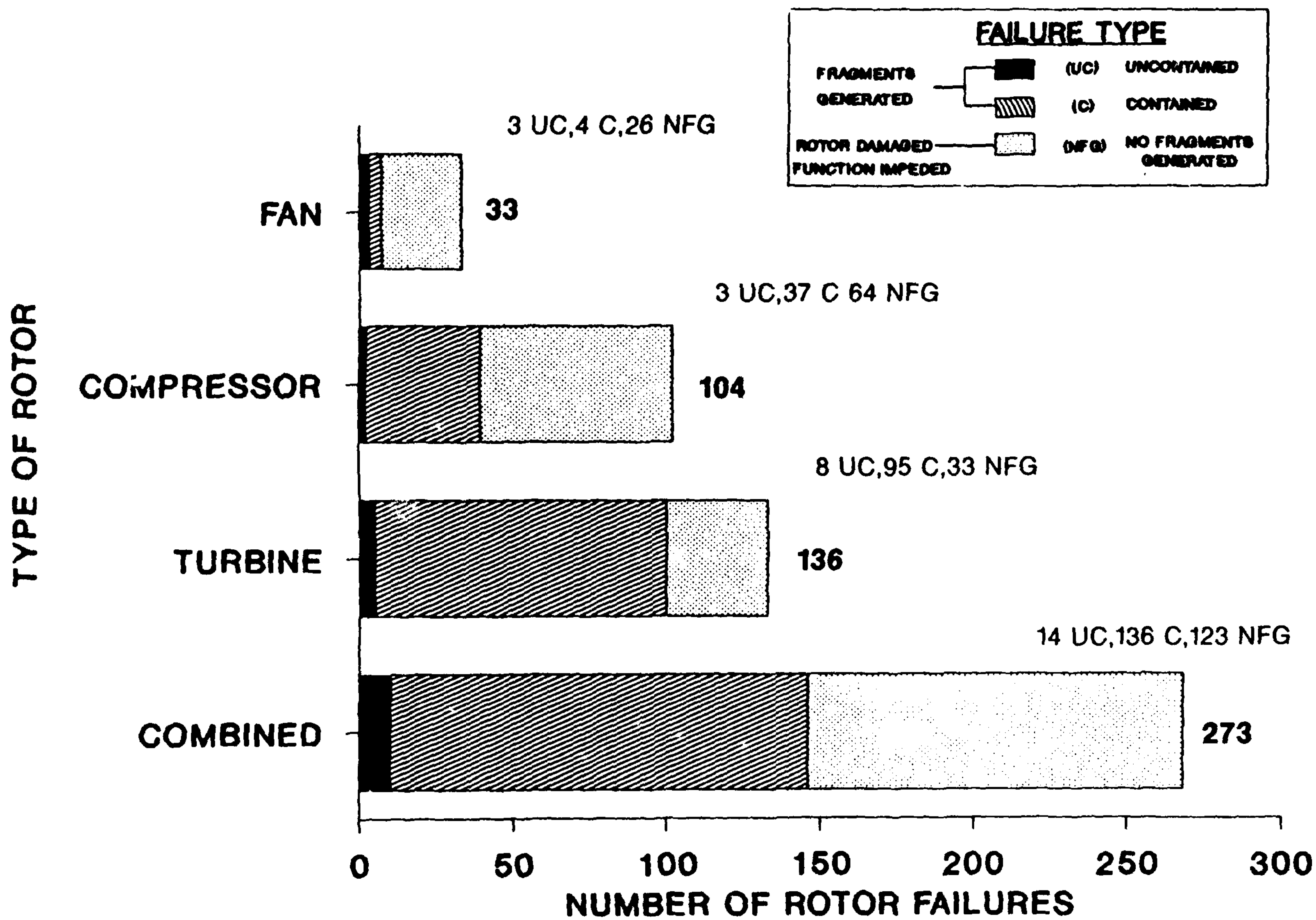


FIGURE 1. INCIDENCE OF ENGINE ROTOR FAILURES IN U.S. COMMERCIAL AVIATION - 1985

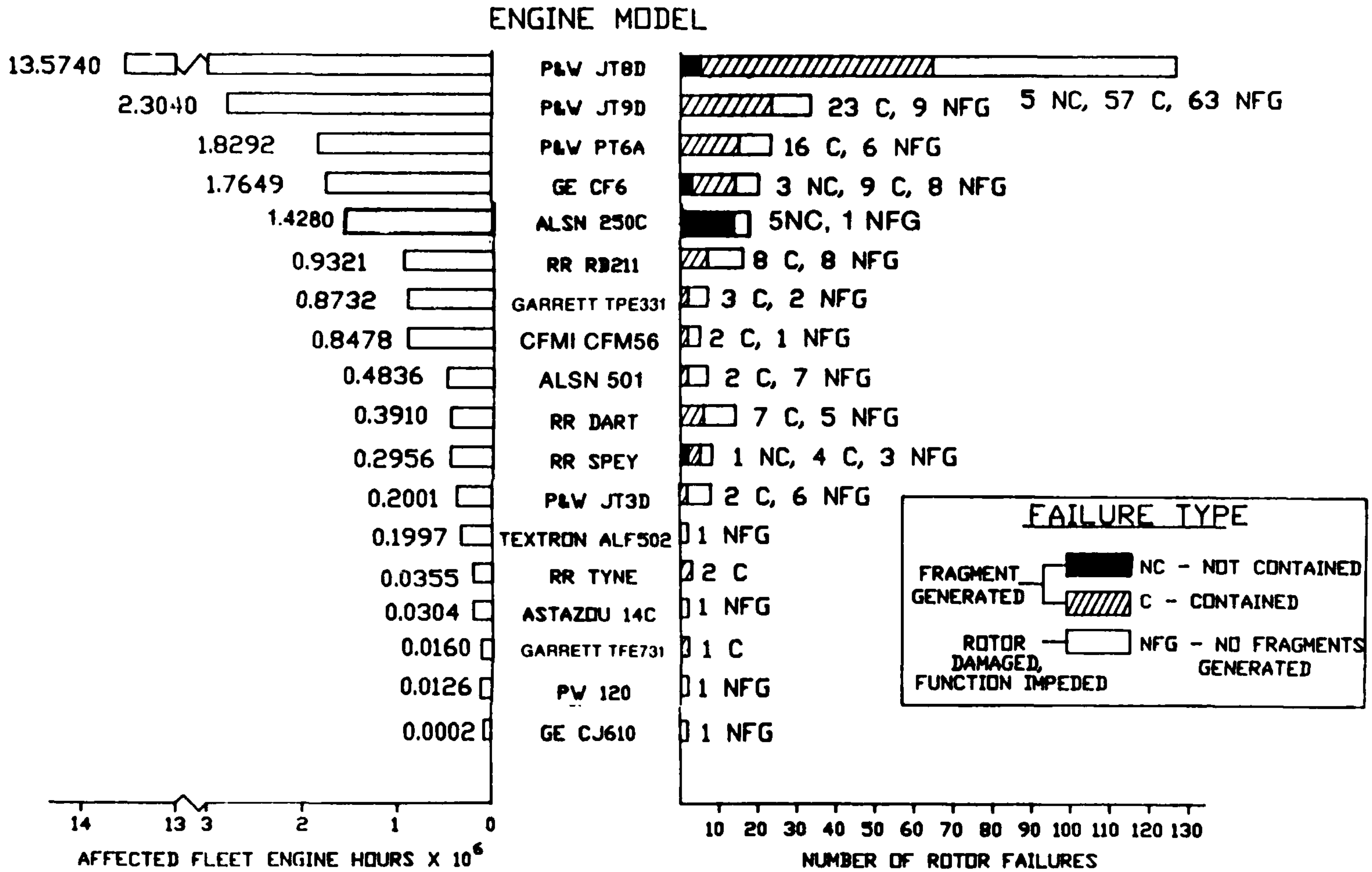


FIGURE 2. INCIDENCE OF ENGINE ROTOR FAILURES IN U.S COMMERCIAL AVIATION ACCORDING TO AFFECTED ENGINE MODEL AND ENGINE FLEET HOURS - 1985

ENGINE ROTOR COMPONENTS	TYPE OF FRAGMENT GENERATED									
	DISK		RIM		BLADE		SEAL		TOTAL	
	TF	UCF	TF	UCF	TF	UCF	TF	UCF	TF	UCF
FAN	0	0	0	0	7	3	0	0	7	3
COMPRESSOR	1	1	0	0	39	2	0	0	40	3
TURBINE	5	5	0	0	96	3	2	0	103	8
TOTAL	6	6	0	0	142	8	2	0	150	14

NOTES:

(1) FAILURES THAT PRODUCED FRAGMENTS

TF - TOTAL FAILURES

UCF - UNCONTAINED FAILURES

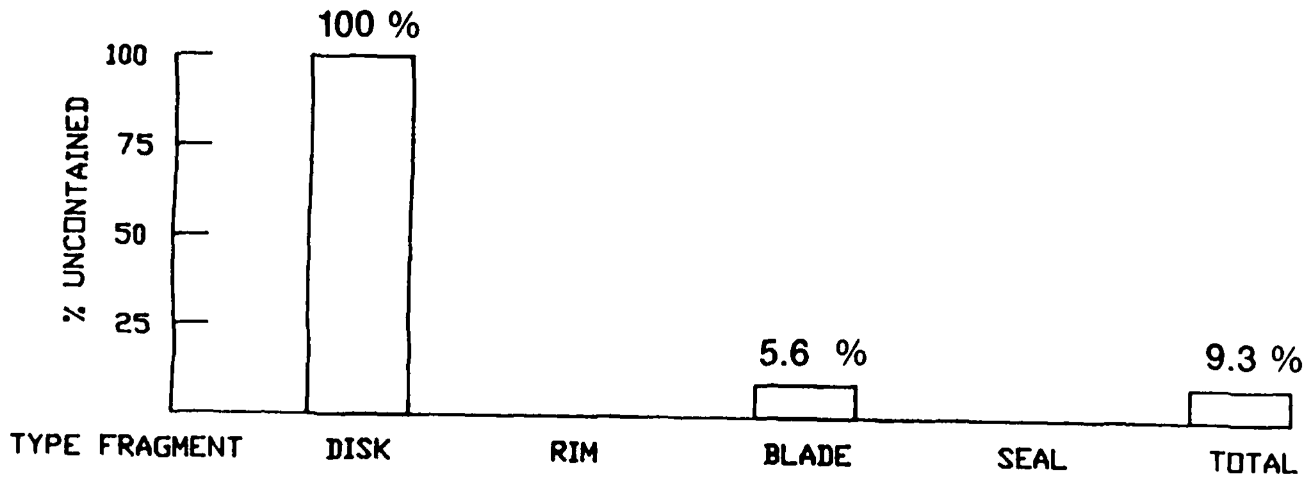
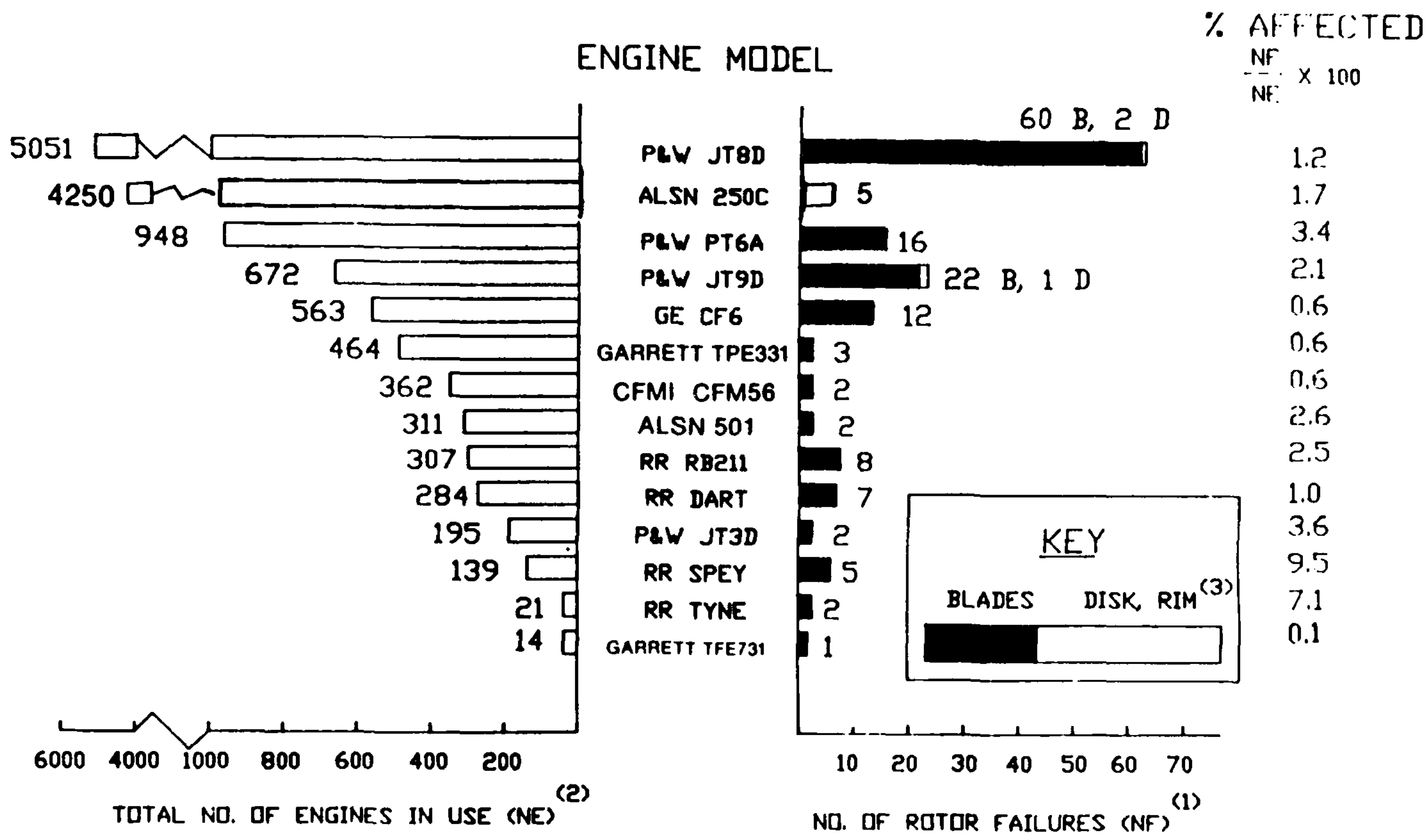


FIGURE 3. COMPONENT AND FRAGMENT TYPE DISTRIBUTIONS FOR CONTAINED AND UNCONTAINED ROTOR ENGINE FAILURES (FAILURES THAT PRODUCED FRAGMENTS) - 1985



NOTES: (1) FAILURES THAT PRODUCED FRAGMENTS
(2) YEARLY AVG. OF AIRCRAFT IN USE AT END OF EACH MONTH
(3) SEAL/SPACER FAILURES INCLUDED IN DISK/RIM COMPILATION

FIGURE 4. THE INCIDENCE OF ENGINE ROTOR FAILURES IN U.S. COMMERCIAL AVIATION ACCORDING TO ENGINE TYPE AFFECTED - 1985

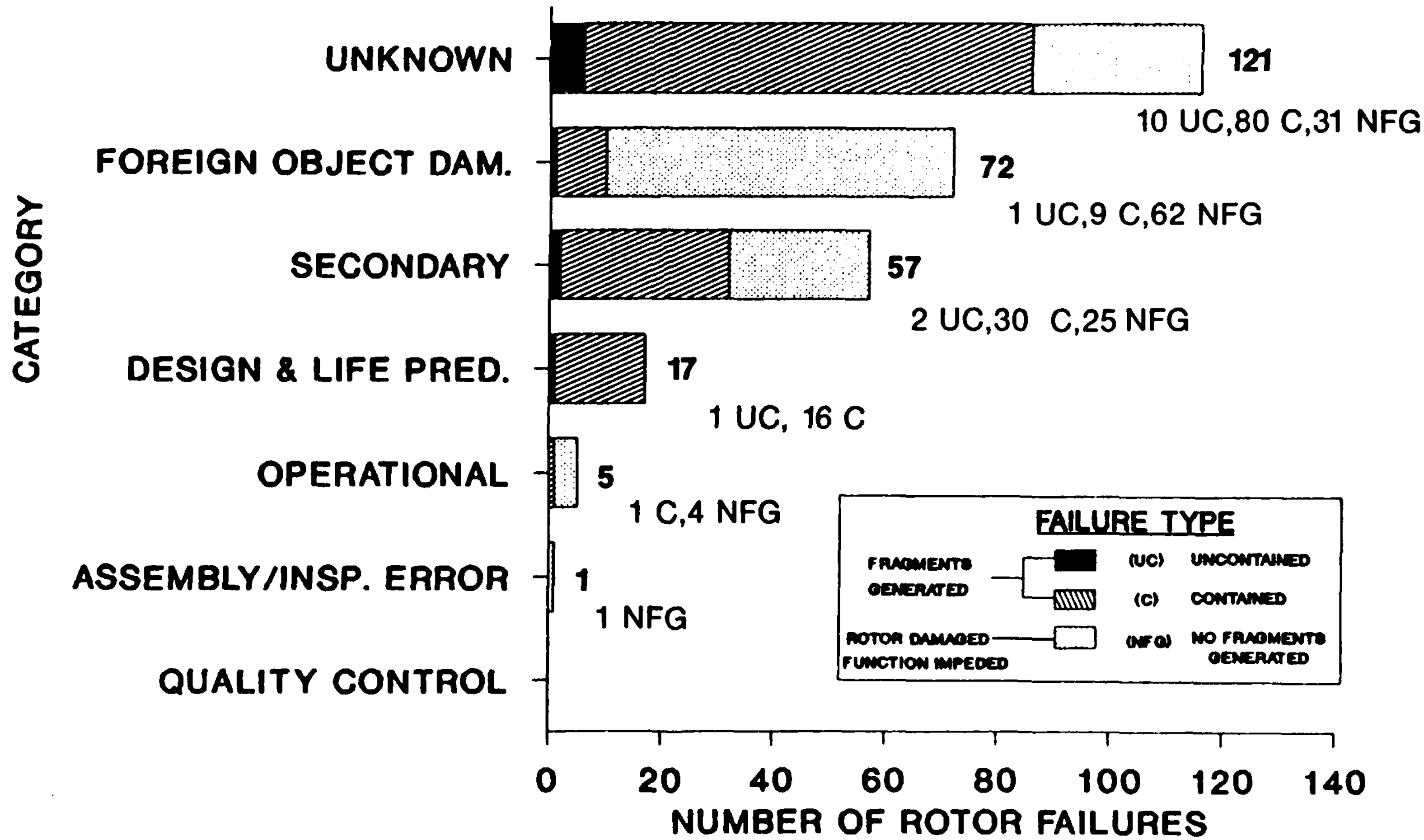


FIGURE 5. ENGINE ROTOR FAILURE CAUSE CATEGORIES - 1985

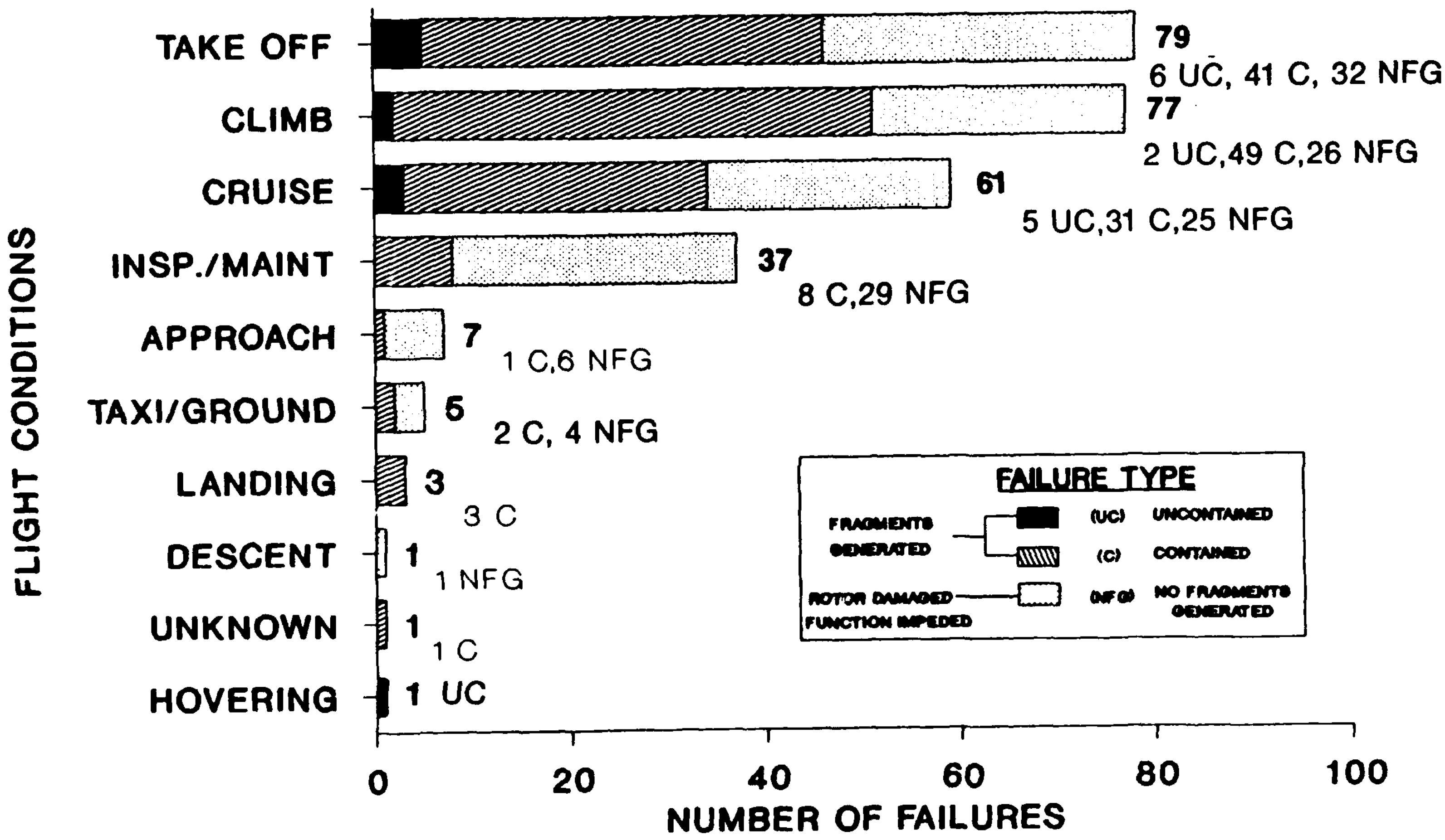


FIGURE 6. FLIGHT CONDITION AT ENGINE ROTOR FAILURE - 1985

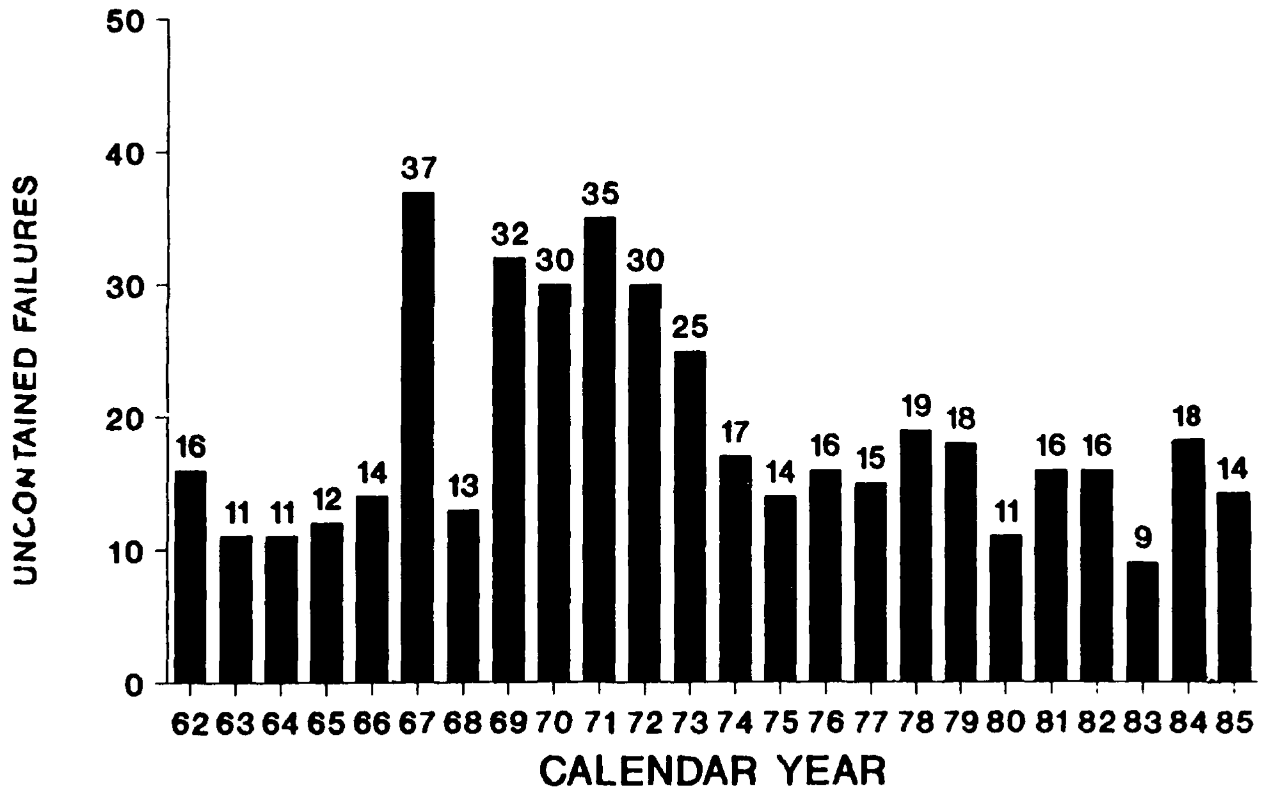


FIGURE 7. THE INCIDENCE OF UNCONTAINED ENGINE ROTOR FAILURES IN U.S. COMMERCIAL AVIATION, 1962-1985

TABLE 1. GAS TURBINE ENGINE FAILURE RATES ACCORDING TO ENGINE MODEL AND TYPE - 1985

TYPE/ MODEL	AVERAGE NUMBER IN USE	ENGINE FLIGHT HRS.x10^6	NO. OF FAILURES				FAIL.RATES / 10^6 ENGINE FLIGHT HRS.			
			C	NC	N	TOTAL	C	NC	N	TOTAL
TURBOFAN/TURBOJET										
JT8D	5051	13.5740	57	5	63	125	4.2	0.4	4.6	9.2
JT3D	195	0.2001	2	0	6	8	10.0	0.0	30.0	40.0
JT9D	672	2.3040	23	0	9	32	10.0	0.0	3.9	13.9
CF6	563	1.7649	9	3	8	20	5.1	1.7	4.5	11.3
RB 211	307	0.9321	8	0	8	16	8.6	0.0	8.6	17.2
CF700	15	0.0065	0	0	0	0	0.0	0.0	0.0	0.0
SPEY	139	0.2956	4	1	3	8	13.5	3.4	10.1	27.1
JT15D	3	0.0006	0	0	0	0	0.0	0.0	0.0	0.0
TFE731	14	0.0160	1	0	0	1	62.5	0.0	0.0	62.5
CFM 56	362	0.8478	2	0	1	3	2.4	0.0	1.2	3.5
ALF 502	77	0.1997	0	0	1	1	0.0	0.0	5.0	5.0
PWA2037	29	0.0770	0	0	0	0	0.0	0.0	0.0	0.0
JT4A	6	0.0020	0	0	0	0	0.0	0.0	0.0	0.0
CJ610	2	0.0002	0	0	1	1	0.0	0.0	5000.0	5000.0
TOTAL	7435	20.2205	106	9	100	215	5.2	0.4	4.9	10.6
TURBOPROP										
PT6A	948	1.8292	16	0	6	22	8.7	0.0	3.3	12.0
ALL501	311	0.4836	2	0	7	9	4.1	0.0	14.5	18.6
TPE331	464	0.8732	3	0	2	5	3.4	0.0	2.3	5.7
DART	284	0.3910	7	0	5	12	17.9	0.0	12.8	30.7
BASTAN	13	0.0225	0	0	0	0	0.0	0.0	0.0	0.0
TYNE	21	0.0355	2	0	0	2	56.3	0.0	0.0	56.3
CT7	19	0.0393	0	0	0	0	0.0	0.0	0.0	0.0
PW120	4	0.0126	0	0	1	1	0.0	0.0	79.4	79.4
TOTAL	2064	3.6869	30	0	21	51	8.1	0.0	5.7	13.8
TURBOSHAFT										
AST14	13	0.0304	0	0	1	1	0.0	0.0	32.9	32.9
250C*	4250	1.4280	0	5	1	6	0.0	3.5	0.7	4.2
ALL OTHERS*	1737	0.5836	0	0	0	0	0.0	0.0	0.0	0.0
TOTAL*	6000	2.0420	0	5	2	7	0.0	2.4	1.0	3.4

C = CONTAINED NC = NOT CONTAINED
N = FUNCTION IMPEDED, NO FRAGMENTS GENERATED

*Estimated total number in use and engine flight hours for entire U.S. commercial fleet.

TABLE 2. UNCONTAINED ENGINE ROTOR FAILURE DISTRIBUTIONS ACCORDING TO CAUSE AND FLIGHT CONDITIONS - 1976 THROUGH 1985

TYPE OF FRAGMENT GENERATED		DISK			RIM			BLADE			SEAL				
ENGINE ROTOR COMPONENT		FAN	COMP	TURB	FAN	COMP	TURB	FAN	COMP	TURB	FAN	COMP	TURB	SUB TOT	TOTAL
CAUSE	FLIGHT COND.														
DESIGN/LIFE	HI	0	5	0	0	2	0	8	8	1	0	1	0	25	
PREDICTION	LOW	0	1	3	0	0	0	1	0	3	0	0	0	8	33
PROBLEMS	UNK	0	0	0	0	0	0	0	0	0	0	0	0	0	
SECONDARY	HI	0	1	0	0	0	0	5	4	18	0	0	3	31	
CAUSES	LOW	0	0	1	0	0	0	0	2	3	0	0	0	6	38
	UNK	0	0	0	0	0	0	0	0	1	0	0	0	1	
FOREIGN	HI	1	0	1	0	0	0	6	0	0	0	0	0	8	
OBJECT	LOW	0	0	0	0	0	0	1	0	0	0	0	0	1	11
DAMAGE	UNK	0	0	0	0	0	0	2	0	0	0	0	0	2	
QUALITY	HI	0	1	0	0	0	1	2	0	0	0	0	0	4	
CONTROL	LOW	0	0	0	0	0	0	0	0	0	0	0	0	0	4
	UNK	0	0	0	0	0	0	0	0	0	0	0	0	0	
OPERATIONAL	HI	0	0	0	0	0	0	0	0	0	0	0	0	0	
	LOW	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	UNK	0	0	0	0	0	0	0	0	0	0	0	0	0	
ASSEMBLY/	HI	0	0	0	0	0	0	0	0	0	0	0	0	0	
INSP.	LOW	0	0	0	0	0	0	0	0	0	0	0	0	0	0
REPORTS	UNK	0	0	0	0	0	0	0	0	0	0	0	0	0	
UNKNOWN	HI	0	2	11	0	3	0	5	9	10	1	2	1	44	
	LOW	1	0	6	0	1	0	0	2	7	0	1	0	18	67
	UNK	0	0	1	0	0	0	1	0	3	0	0	0	5	
	HI	1	9	12	0	5	1	26	21	29	1	3	4	112	
SUBTOTAL	LOW	1	1	10	0	1	0	2	4	13	0	1	0	33	153
	UNK	0	0	1	0	0	0	3	0	4	0	0	0	8	
TOTAL			35			7			102			9		153	153

*Takeoff and climb are defined as "High Power" and all other conditions are defined as "Low Power"

APPENDIX A

Data of Engine Rotor Failures in U.S. Commercial Aviation for 1985. Compiled from the Federal Aviation Administration Service Difficulty Reports.

Data Compilation Key

Component Code:
- F - Fan
- C - Compressor
- T - Turbine

Fragment Type Code:
- D - Disk
- R - Rim
- B - Blade
- S - Seal
- N - None

Cause Code:
- 1 - Design and Life Prediction Problems
- 2 - Secondary Causes
- 3 - Foreign Object Damage
- 4 - Quality Control
- 5 - Operational
- 6 - Assembly and Inspection Error
- 7 - Unknown

Containment Condition Code:
- C - Contained
- NC - Not Contained
- N - No Fragments Generated

Flight Condition Code:
- 1 - Insp/Maint
- 2 - Taxi/Grnd Hdl
- 3 - Takeoff
- 4 - Climb
- 5 - Cruise
- 6 - Descent
- 7 - Approach
- 8 - Landing
- 9 - Hovering
- 10 - Unknown

CHARACTERISTICS OF ROTOR FAILURES - 1985

SDR NO.	SUBMITTER	AIRCRAFT	ENG/LOC	COMPONENT	FRAGMENT TYPE	CAUSE	CONTAINMENT CONDITION	FLIGHT CONDITION
850417068	NYAA	DC9	JT8D	C	B	7	C	3
850424052	MACA	DC9	JT8D	C	B	7	C	3
850614005	MACA	DC9	JT8D	C	B	7	C	4
850624006	REPA	OC9	JT8D	C	B	7	C	4
850415089	UALA	B727	JT8D	C	B	7	C	5
850930122	UALA	B727	JT8D	F	B	2	C	3
850513051	EALA	B727	JT8D	C	B	7	C	5
850806058	EALA	B727	JT8D	C	B	2	C	5
851121043	EALA	B727	JT8D	C	B	2	C	5
851230041	EALA	B727	JT8D	C	B	2	C	3
851209137	DALA	B727	JT8D	F	B	3	C	8
851217018	EALA	B727	JT8D/No.3	C	B	7	NC	3
851217014	USAA	DC9	JT8D	C	B	3	C	3
850225096	MIDA	DC9	JT8D	T	B	1	C	4
850304080	MIDA	DC9	JI8D	T	B	1	C	4
850208056	USAA	DC9	JT8D	T	B	7	C	3
850304160	USAA	DC9	JT8D	T	B	1	C	3
850326032	MIDA	DC9	JT8D	T	B	7	C	4
850724003	NYAA	DC9	JT8D	T	B	1	C	5
850823024	OZAA	DC9	JT8D	T	B	7	C	3
850829011	EALA	DC9	JT8D	T	B	7	C	4
851003010	PSAA	DC9	JT8D	T	B	7	C	3
851220082	REPA	DC9	JT8D	T	B	7	C	4
850909116	NYAA	DC9	JT8D	T	B	1	C	3
850103048	EALA	DC9	JT8D	T	B	1	C	5
850422086	ACLA	DC9	JT8D	T	B	7	C	8
850926004	JAMA	DC9	JT8D	T	B	7	C	3
851129189	REPA	DC9	JT8D	T	B	1	C	4
851202225	JAMA	DC9	JT8D	T	B	7	C	3
851209146	REPA	DC9	JT8D	T	B	1	C	4
850304149	ATEA	B727	JT8D	T	B	7	C	3
850715008	UALA	B727	JT8D	T	B	7	C	4
850422084	EALA	B727	JT8D	T	B	2	C	4
850507006	EALA	B727	JT8D	T	B	7	C	5
850716010	EALA	B727	JT8D	T	B	7	C	4
850724005	EALA	B727	JT8D	T	B	2	C	3
850806066	EALA	B727	JT8D	T	B	2	C	5
850926014	EALA	B727	JT8D	T	B	7	C	5
851231005	PEXA	B727	JT8D	T	B	7	C	4
850820030	TWAA	B727	JT8D	T	B	2	C	3
850926005	TWAA	B727	JT8D	T	B	2	C	4
851209150	TWAA	B727	JT8D	T	B	7	C	4
850121121	NWAA	B727	JT8D	T	B	7	C	4
850121120	TWAA	B727	JT8D	T	B	7	C	4

CHARACTERISTICS OF ROTOR FAILURES - 1985

SDR NO.	SUBMITTER	AIRCRAFT	ENG/LOC	COMPONENT	FRAGMENT TYPE	CAUSE	CONTAINMENT CONDITION	FLIGHT CONDITION
850129092	TWAA	B727	JT8D	T	B	7	C	4
850507015	TWAA	B727	JT8D	T	B	1	C	5
850924043	IASA	B727	JT8D	T	B	7	C	3
850304152	ACLA	B737	JT8D	T	B	7	C	3
850109074	SWAA	B737	JT8D	T	B	2	C	8
850501039	SWAA	B737	JT8D	T	S	1	C	4
850702028	PAAA	B737	JT8D/No.2	T	B	7	NC	5
850205060	FALA	B737	JT8D	T	B	7	C	3
851231008	UALA	B727	JT8D	T	B	2	C	3
850213075	SW99	B737	JT8D/No.2	T	D	7	NC	3
851220078	USAA	DC9	JT8D	C	B	3	C	3
850206020	MIDA	DC9	JT8D	C	B	2	C	5
850424050	USAA	DC9	JT8D/No.1	C	B	1	NC	3
850724006	REPA	DC9	JT8D	C	B	7	C	4
851209144	EALA	DC9	JT8D	C	B	3	C	3
850124018	HALA	DC9	JT8D	C	B	2	C	3
851205046	HALA	DC9	JT8D/No.2	F	B	7	NC	3
850614008	HALA	DC9	JT8D	C	B	7	C	4
851119130	HALA	DC9	JT8D	T	N	7	N	1
851022029	HALA	DC9	JT8D	C	N	3	N	4
851017062	HALA	DC9	JT8D	F	N	3	N	1
851017061	HALA	DC9	JT8D	F	N	3	N	1
851017030	HALA	DC9	JT8D	C	N	3	N	1
851007060	HALA	DC9	JT8D	C	N	3	N	1
850829014	HALA	DC9	JT8D	C	N	3	N	1
850829012	HALA	DC9	JT8D	C	N	3	N	1
850823023	HALA	DC9	JT8D	C	N	3	N	1
850501040	REPA	DC9	JT8D	C	N	3	N	3
850212058	FTLA	B727	JT8D	F	N	3	N	3
850116039	AGLA	B737	JT8D	F	N	3	N	1
851205050	AGLIA	B737	JT8D	F	N	3	N	7
850116040	HIDA	DC9	JT8D	C	N	3	N	3
850521014	EALA	B727	JT8D	C	N	3	N	1
851205051	EMAA	DC9	JT8D	C	N	2	N	1
850614009	USAA	DC9	JT8D	C	N	3	N	5
850627003	REPA	DC9	JT8D	C	N	6	N	3
850227038	HALA	DC9	JT8D	C	N	7	N	5
850227039	HALIA	DC9	JT8D	C	N	7	N	5
850318103	MIDA	DC9	JT8D	C	N	7	N	4
850401074	JAMA	DC9	JT8D	C	N	3	N	5
850610099	HALA	DC9	JT8D	C	N	7	N	4
851119132	HALA	DC9	JT8D	C	N	7	N	1
851125108	HALA	DC9	JT8D	C	N	3	N	1
851125109	HALA	DC9	JT8D	F	N	3	N	1
851209130	HALA	DC9	JT8D	F	N	3	N	1

CHARACTERISTICS OF ROTOR FAILURES - 1985

SDR NO.	SUBMITTER	AIRCRAFT	ENG/LOC	COMPONENT	FRAGMENT TYPE	CAUSE	CONTAINMENT CONDITION	FLIGHT CONDITION
851210057	HALA	DC9	JT8D	F	N	3	N	1
851210058	HALA	DC9	JT8D	F	N	3	N	1
850417066	NYAA	DC9	JT8D	F	N	2	N	2
850910030	REGA	B727	JT8D	C	N	7	N	5
850722007	REPA	B727	JT8D	C	N	7	N	5
850115044	PAAA	B727	JT8D	C	N	7	N	3
850208048	UALA	B727	JT8D	C	N	3	N	3
850206018	RYNA	B727	JT8D	C	N	3	N	1
850123022	FILA	B727	JT8D	F	N	3	N	3
850208061	PEXA	B727	JT8D	C	N	3	N	3
851209136	PEXA	B727	JT8D	C	N	3	N	5
850227037	ISAA	B727	JT8D	F	N	3	N	7
850312001	NIAA	B727	JT8D	C	N	2	N	4
850304157	RYNA	B727	JT8D	F	N	3	N	3
850409056	PEXA	B727	JT8D	C	N	3	N	4
850715007	PETA	B737	JT8D	C	N	3	N	4
850903098	AWXA	B737	JT8D	C	N	2	N	5
850225091	SWAA	B737	JT8D	C	N	2	N	3
850424055	SWAA	B737	JT8D	F	N	3	N	3
850521019	SWAA	B737	JT8D	F	N	3	N	4
851209140	SWAA	B737	JT8D	F	N	3	N	3
850321064	AWXA	B737	JT8D	F	N	3	N	7
850304155	ACLA	B737	JT8D	F	N	3	N	7
850722005	ACLA	B737	JT8D	C	N	3	N	5
850909008	ACLA	B737	JT8D	C	N	2	N	3
851209151	ACIA	B737	JT8D	C	N	3	N	3
851231017	ACLA	B737	JT8D	C	N	3	N	1
850103050	REPA	DC9	JT8D	T	N	2	N	5
850924039	TAGA	B727	JT8D	T	N	7	N	4
850208050	EALA	B727	JT8D	T	N	2	N	4
850507005	EALA	B727	JT8D	T	N	7	N	5
850605015	PAAA	B727	JT8D	T	N	7	N	4
851003004	PRDA	B727	JT8D	T	N	7	N	4
850115045	AFLA	B737	JT8D	T	N	7	N	3
851127093	MACA	DC9	JT8D	F	N	3	N	3
850129079	UALA	B727	JT8D	F	N	3	N	3
850318105	NWAA	DC10	JT9D	C	B	7	C	4
850312016	TWAA	B747	JT9D	C	B	3	C	5
851010003	TWAA	B747	JT9D	C	B	3	C	5
850716009	NWAA	B747	JT9D	C	B	7	C	3
850304164	JCSA	DC10	JT9D	T	B	7	C	4
850610092	NWAA	DC10	JT9D	T	B	7	C	4
850617034	NWAA	DC10	JT9D	T	B	2	C	3
850905039	TWRA	B747	JT9D	T	B	7	C	4
850813080	TIAA	B747	JT9D	T	B	1	C	3
850528123	TWAA	B747	JT9D	T	B	7	C	1

CHARACTERISTICS OF ROTOR FAILURES - 1985

SDR NO.	SUBMITTER	AIRCRAFT	ENG/LOC	COMPONENT	FRAGMENT TYPE	CAUSE	CONTAINMENT CONDITION	FLIGHT CONDITION
850521007	TWAA	B747	JT9D	T	B	7	C	3
850624010	TWAA	B747	JT9D	T	B	7	C	5
851231012	TWAA	B747	JT9D	T	B	1	C	4
851129190	TWAA	B747	JT9D	T	B	7	C	4
850926007	TWAA	B747	JT9D	T	B	7	C	4
850312004	NWAA	B747	JT9D	T	B	7	C	4
850909110	NWAA	B747	JT9D	T	B	7	C	4
851125101	NWAA	B747	JT9D	T	B	7	C	4
850828007	TWAA	B747	JT9D	T	B	2	C	5
850909115	TWAA	B747	JT9D	T	B	2	C	4
850516020	TWAA	B747	JT9D	T	S	7	C	4
850225092	TWAA	B747	JT9D	T	B	1	C	3
851209127	TWAA	B747	JT9D	T	B	2	C	3
850107067	TWAA	B747	JT9D	T	N	2	N	4
850205058	TWAA	B747	JT9D	F	N	3	N	3
850415086	JCSA	DC10	JT9D	F	N	3	N	3
850610091	NWAA	B747	JT9D	C	N	2	N	4
850903100	NWAA	B747	JT9D	C	N	3	N	3
850507009	FILAA	B747	JT9D	F	N	3	N	1
850121119	UACA	B747	JT9D	F	N	3	N	3
850121112	UALA	B767	JT9D	C	N	3	N	5
850729048	TWAA	B747	JT9D	T	N	5	N	1
850822022	WALA	DC10	CF6	T	B	1	C	4
851230033	EALA	A300	CF6	C	B	7	C	4
850521011	EALA	A300	CF6/No.2	F	B	3	NC	4
851023054	EALA	A300	CF6	C	B	2	C	4
851209129	WRLA	DC10	CF6	F	B	3	C	3
850409057	CALA	DC10	CF6	F	B	3	C	3
850926012	WRLA	DC10	CF6	C	B	2	C	3
850624007	AALA	DC10	CF6	T	B	7	C	5
850709011	WALA	DC10	CF6	T	B	7	C	3
850828004	WALA	DC10	CF6	T	B	7	C	4
850919046	WRLA	DC10	CF6/No.2	T	B	7	NC	4
851023055	AALA	DC10	CF6/Unk.	T	B	7	NC	5
850709010	AALA	DC10	CF6	C	N	2	N	4
850909005	AALA	DC10	CF6	C	N	7	N	4
850813086	EALA	A300	CF6	T	N	2	N	7
850910031	EALA	A300	CF6	T	N	2	N	4
850905040	AALA	DC10	CF6	T	N	2	N	4
851230055	ARWA	DC10	CF6	T	N	2	N	4
850610094	TIAA	B747	CF6	T	N	7	N	4
850820032	TIAA	B747	CF6	T	N	7	N	1
850108116	QXEA	SA227	TPE331	C	N	3	N	7

CHARACTERISTICS OF ROTOR FAILURES - 1985

SDR NO.	SUBMITTER	AIRCRAFT	ENG/LOC	COMPONENT	FRAGMENT TYPE	CAUSE	CONTAINMENT CONDITION	FLIGHT CONDITION
850510100	QXEA	SA227	TPE331	T	N	3	N	1
850926076	SWIA	SA226	TPE331	T	B	7	C	4
850404016	QXEA	SA227	TPE331	T	B	7	C	3
850801002	MAAA	SA227	TPE331	T	B	7	C	5
851129175	SSIA	B707	JT3D	C	N	7	N	5
851125094	SRAA	B707	JT3D	C	N	3	N	4
851217010	SSIA	B707	JT3D	C	N	7	N	5
850304167	RDLA	DC8	JT3D	T	N	7	N	5
850813077	UACA	DC8	JT3D	T	N	7	N	5
850208059	FWIA	B707	JT3D	T	N	2	N	1
851230044	ARWA	DC8	JT3D	T	B	7	C	4
850326026	FWIA	B707	JT3D	T	B	7	C	1
850930128	TIAA	382	501	C	N	3	N	5
850415093	SMMA	STCAPJC	501	C	N	3	N	3
851125102	SRAA	382	501	C	N	3	N	3
850930129	TIAA	382	501	C	N	3	N	4
850610089	TIAA	382	501	C	N	3	N	3
851217021	TIAA	382	501	C	N	3	N	3
851230045	ASPA	STCAPJC	501	T	N	2	N	5
850529001	TIAA	382	501	T	B	7	C	4
850610097	TIAA	382	501	T	B	7	C	4
850821069	EALA	CL44	TYNE515	C	B	7	C	4
850222030	WRNA	CL44	TYNE515	T	B	7	C	5
850212059	UALA	DC8	CFM56	C	N	3	N	3
850930124	TIAA	DC8	CFM56	T	B	2	C	5
850715011	ACLA	B737	CFM56	T	B	2	C	5
850130029	ERAA	240	CJ610	C	N	3	N	5
850730003	AVCA	HS125	TFE731	T	B	7	C	5
851217034	APHA	BAE146	ALF502	T	N	7	N	5
850705075	SW62	AS355	250C	C	N	7	N	2
851018077	DHLA	206L	250C	T	D	2	NC	5
851126036	SW62	206L	250C	C	D	7	NC	9
850522059	SW62	BO105C	250C/Unk.	T	D	7	NC	5
850801009	SW62	206L	250C	T	D	7	NC	3
850605015	SW62	BO105C	250C/Unk.	T	D	7	NC	5
850219020	MWAA	SD330	PT6A	T	N	7	N	5
850528126	RANA	DHC7	PT6A	C	N	2	N	6
850429049	RMAA	DHC7	PT6A	T	N	2	N	2
850703082	HWAA	DHC7	PT6A	T	N	2	N	1
851010002	SALA	SD330	PT6A	T	N	2	N	4
850806060	SIMA	SD330	PT6A	T	B	7	N	3
850717002	PREA	B99	PT6A	T	B	5	C	5
851004019	RAYA	EMB110	PT6A	C	B	7	C	2

CHARACTERISTICS OF ROTOR FAILURES - 1985

SDR NO.	SUBMITTER	AIRCRAFT	ENG/LOC	COMPONENT	FRAGMENT TYPE	CAUSE	CONTAINMENT CONDITION	FLIGHT CONDITION
850812055	AKIA	EMB110	PT6A	C	B	7	C	5
851209158	ASOA	SD360	PT6A	C	B	2	C	5
851003078	AKYA	B99	PT6A	T	B	7	C	4
850621076	ERAA	DHC6	PT6A	T	B	2	C	1
850117030	RMAA	DHC6	PT6A	T	B	7	C	4
850828149	SCIA	DHC6	PT6A	T	B	7	C	3
851008103	RMAA	DHC6	PT6A	T	B	7	C	4
851127039	SCIA	DHC6	PT6A	T	B	7	C	3
850108132	ASOA	EMB110	PT6A	T	B	7	C	7
850314060	IMPA	EMB110	PT6A	T	B	7	C	5
851129256	RAYA	EMB110	PT6A	T	B	7	C	4
850402048	PCAA	SD330	PT6A	T	B	7	C	3
850930131	WTAA	SD330	PT6A	T	B	7	C	3
850709008	RANA	STC262	PT6A	T	B	7	C	5
851119112	HNAA	DHC8	PW120	C	N	7	N	1
850819009	HPJA	HP137	ASTAZOU14C	C	N	2	N	5
851205061	PAIA	F28	SPEY555/No.1	F	B	2	NC	3
850215018	EMPA	F28	SPEY555	C	B	7	C	5
850923081	EMPA	F28	SPEY555	C	B	7	C	3
850930120	USAA	BAC111	SPEY506	C	B	2	C	5
850529004	PLGA	F28	SPEY	T	B	7	C	1
851217024	MPCA	F28	SPEY555	C	N	3	N	1
851007062	USAA	BAC111	SPEY506	C	N	3	N	5
850409052	CCOA	BAC111	SPEY	T	N	7	N	4
850507004	TWAA	L1011	RB211	C	B	2	C	4
850109032	TWAA	L1011	RB211	C	B	3	C	1
850730004	EALA	L1011	RB211	C	B	2	C	3
850109033	TWAA	L1011	RB211	C	B	1	C	5
850115048	EALA	L1011	RB211	C	B	2	C	4
850121109	EALA	L1011	RB211	C	B	2	C	5
851230048	TWAA	L1011	RB211	C	B	2	C	4
850109030	TWAA	L1011	RB211	T	B	1	C	1
850923025	EALA	L1011	RB211	C	N	3	N	5
850730002	EALA	L1011	RB211	F	N	3	N	3
850225062	EALA	L1011	RB211	C	N	5	N	4
850417064	AMTA	L1011	RB211	F	N	5	N	3
850513060	EALA	L1011	RB211	C	N	2	N	5
850513061	EALA	L1011	RB211	C	N	2	N	5
850813081	TWAA	L1011	RB211	C	N	2	N	4
851205054	EALA	B757	RB211	C	N	3	N	4
850521005	BRIA	FH227	DART	T	B	7	C	1
850521006	BRIA	FH227	DART	T	B	7	C	10
850225095	BRIA	FH227	DART	T	B	7	C	3

CHARACTERISTICS OF ROTOR FAILURES - 1985

SDR NO.	SUBMITTER	AIRCRAFT	ENG/LOC	COMPONENT	FRAGMENT TYPE	CAUSE	CONTAINMENT CONDITION	FLIGHT CONDITION
850521013	BRIA	F27	DART	T	B	7	C	1
850521022	BRIA	F27	DART	T	B	7	C	3
850610087	PLGA	F27	DART	T	B	2	C	5
850507010	WRTA	STC340	DART	T	B	7	C	2
850708001	BRIA	G159	DART	T	N	5	N	1
850130033	SMBA	STC240	DART	T	N	7	N	3
850605019	SMBA	STC240	DART	T	N	7	N	3
851009004	SMBA	STC240	DART	T	N	7	N	1
851009007	SMBA	STC240	DART	T	N	7	N	3

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